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The Border-Line between Meteorology and Soil Physics

By DR. B. A. KEEN,

Assistant Director and Head of the Soil Physics Department, Rothamsted Experimental Station.

IT would not be correct to say that the meteorologist loses interest in the rain once it has fallen, and the farmer, except at harvest time, has no interest in rain until it has fallen and entered the soil; nevertheless there is a good deal of truth in the statement, and the difference in the interest of these two classes is shown by the fact that the border-line—the relations between precipitation and the amount of moisture in the soil under varying conditions—has been little explored. The purpose of this short article is to discuss in a simple manner some of the investigations in the Soil Physics Department at Rothamsted, and elsewhere, that fall on this border-line.

The farmer is concerned with the moisture content of the top few feet of soil, and is not interested in the moisture that penetrates to lower depths except in so far as this may subsequently become available for farm purposes by pumping, or in low-lying places by ponds, or by capillary action to the plant roots in periods of drought. For agricultural purposes, therefore, it is important to know approximately what proportion of the rainfall is left behind in the upper layers of the soil. The records of the Rothamsted drain gauges give invaluable aid in this respect. They were erected in 1870, and consist of three blocks of bare

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and undisturbed soil 1/1000 acre in area and respectively 20 in., 40 in. and 60 in. in depth. Collecting and measuring vessels were installed in special chambers underneath each of these blocks. The long series of records from these gauges enable reliable average values to be obtained. Taking the figures on a yearly basis, and dividing them into three groups of low, normal and heavy rainfall, we obtain the following results :—

	Rainfall	Drainage		Evaporation
	in.	in.	%	in.
Below 26 in.	23·67	10·12	42·8	13·55
26 in.—30 in.	28·49	14·08	49·4	14·41
Above 30 in.	33·62	17·66	52·5	15·96

Thus, in the Rothamsted soil, a heavy loam typical of large areas in the country, about half of the rainfall appears as percolation water. The percentage increases with increase in the annual rainfall, as could be expected, since wet years are usually below the average in sunshine, and evaporation is correspondingly reduced. The fifth column headed " evaporation " is the difference between yearly rainfall and yearly percolation. It is not an absolutely exact measurement of the evaporation as it implies the assumption that the actual moisture content of the block of soil at the end of the year is always constant. This is sufficiently near the truth when dealing with yearly averages.

The proportions of drainage and evaporation naturally differ from month to month. Average values are shown in the follow-

Monthly Amounts of Drainage through 60 inches of Soil. Average of 45 Years (1870-1, 1914-5).

Month	Rainfall	Drainage	Drainage	Evaporation
	in.	in.	%	in.
September ..	2·30	0·64	27·8	1·66
October ..	3·27	1·69	51·8	1·58
November ..	2·81	2·04	72·6	0·77
December ..	2·78	2·29	82·4	0·49
January ..	2·31	1·97	85·3	0·34
February ..	2·01	1·49	74·1	0·52
March ..	2·04	1·13	55·4	0·91
April ..	1·87	0·55	29·4	1·32
May ..	2·07	0·50	24·2	1·57
June ..	2·44	0·65	26·6	1·79
July ..	2·58	0·60	23·3	1·98
August ..	2·66	0·62	23·3	2·04

ing table ; the approximate nature of the figures in the last column must again be remembered.

The trend of the seasonal fluctuations is clear from this table. In the summer the land is more or less dried out and only a small proportion of the rain percolates to a 60 in. depth. The rest is held by the soil and in large part evaporated again. With the approach of winter the evaporation is much reduced, and the moisture content of the soil increases towards its saturation value. Hence in the winter months percolation forms a high percentage of the rainfall.

There are certain respects in which the drain gauge conditions inevitably differ from those in the field. In the latter an unknown proportion of rain may run off along the surface to a lower contour whenever the rate of fall of the rain exceeds the rate at which the soil can absorb it. This is prevented in the drain gauge by the raised edges.

Another difference is inherent in the design of the drain gauges. Whereas in the field the soil material is generally continuous down to the ground water level, in the drain gauges it ceases at the bottom of the gauge. This difference has important significance in connexion with the vertical distribution of moisture in the soil. If a tube of soil previously saturated with water is allowed to stand in a vertical position with the bottom in water, it will begin to discharge at the lower end, and eventually the distribution of water will show a gradual decrease from the bottom to the top. If in addition the top of the tube has also been exposed to evaporation, the moisture content of the top layers of soil will show a sharper drop. In either case this gradient is maintained against the action of gravity by the surface tension effects due to the water films in the interstices between the particles assuming a curvature that increases with their distance from the bottom of the tube. It takes a long time for this equilibrium distribution to be established under laboratory conditions, and in the field it is never attained, owing to the alterations of temperature, changes in the intensity of evaporation and the intermittent disturbances due to rain.

The position is further complicated by the change in physical structure of the field soil at increasing depths. Unlike the soil in the tube which is uniform from top to bottom, in the field soil below the depth of cultivation a marked change in colour can be seen, and this is associated with other changes, such as a decrease in pore space and increase in clay content. The nearest approach to equilibrium moisture conditions is during a drought. In this connexion results obtained at Rothamsted on a fallow plot just before the break of the great drought of 1921, and during the recent drought (July, 1925), are of interest especially in com-

parison with the values for an adjacent plot carrying a thin crop of wheat.

Great Drought, 1921				July Drought, 1925			
Fallow		Cropped		Fallow		Cropped	
Depth	Moisture	Depth	Moisture	Depth	Moisture	Depth	Moisture
in.	%	in.	%	in.	%	in.	%
0—1¼	2·47			0—2	4·55	0—2	7·7
		0—4½	4·04				
1¼—4	17·81			2—4	4·75	2—4	7·05
				4—5	8·3	4—5	7·35
4—6½	15·41	4½—6¾	6·11				
				5—6½	15·4	5—6½	7·35
6½—9	15·85	6¾—9	11·06	6½—9	19·3	6½—9	8·2
9—13½	17·98	9—13½	13·54	9—13½	21·6	9—13½	12·1
13½—18	20·61	13½—18	14·09	13½—18	22·3	13½—18	15·0
18—27	26·18			18—24	26·0	18—24	15·3
						31—34	18·4

Near the surface the moisture content in the fallow soil falls off very rapidly. This is primarily due to the effects of winds and heat in drying the top layer which then acts as a dry mulch or blanket, and reduces the rate at which the moisture in the soil below this layer can evaporate. The division between the mulch and the soil is very sharp, the former being dry and dusty and the latter distinctly moist. Below the dry layer the water content increases slowly with depth as indicated by the laboratory experiment ; but part of this increase is accounted for by the increase in clay content of the sub-soil, which makes the soil " heavier " and therefore able to hold larger amounts of water. Perhaps the most striking feature of the table is the difference between the fallow and cropped values. The latter are much lower over the top 18 in., and in the 1925 series are much more regular. This is due to the absorption by the roots which have reduced the moisture content fairly uniformly over their range of travel. The uniform moisture distribution extends to the top layer of the soil which is protected by the crop from the intense drying effect of wind and sun seen on the fallow soil.

This brings us naturally to the general question of movement of water in the soil. We have already touched on two important causes, evaporation at the surface and downward flow due to gravitation. When the pore space of a soil is full of water, the latter effect is comparatively simple, and in principle the ordinary

Poiseuille capillary tube law can be applied. The "capillary tubes" are irregular in length, width and direction, but a satisfactory statistical average can be used. Alternatively the problem can be attacked by postulating an "ideal soil," consisting of a mass of equal sized spheres packed together in a systematic manner. Calculation of dimensional properties of the pores between the spheres is then a matter of solid geometry. A monumental investigation of this nature made by Slichter in America in 1899 was closely followed experimentally by King, who was able in general to substantiate the conclusions for the flow of water through saturated soils. The main interest of this work, however, was in giving precision to questions of water-supply to fairly deep wells supplied by percolation along water bearing strata. It did not apply directly to water movements in the top layers of soil in which normally an appreciable proportion of pore space is occupied by air as shown in the following table :—

PORE SPACE, WATER CONTENT AND AIR CONTENT OF CERTAIN ROTHAMSTED SOILS.

	Loss on Ignition (Organic Matter etc.)	Volume Occupied in Natural State by		Volume of Water		Volume of Air	
		Solid Matter	Air and Water (Pore Space)	In Normal Moist State	After Period of Drought	In Normal Moist State	After Period of Drought
	% weight						
Arable—Unmanured	4·3	66	34	23	17	11	17
Arable—14 tons dung per annum	10·0	62	38	30	20	8	18
Pasture	13·0	53	47	40	22	7	25

In these conditions the water is distributed as a thin coating over the soil particles and tends to concentrate in the interstices between the grains, as already mentioned in the case of the vertical tube of soil. Movement of water then takes place either by distillation from a warmer to a cooler region or under the effects of surface tension, water being drawn from moisture regions where the curvature of the intersticial water wedges is less, to adjacent dryer spots where the shrunken films have a sharper curvature.

The former effect follows the diurnal temperature wave in its downward penetration in the day, and its upward flow at night; the latter effect serves to promote a movement of water to an absorbing plant root from the immediate surrounding volume, and towards the surface of the soil when this is depleted of water by evaporation. Theoretical considerations and experiment both indicate that the distances over which appreciable water

movement can be initiated by these factors are very small: the plant root does not wait for, but goes in search of the moisture. On the other hand, the physical causes of water movement would appear to be of great importance in maintaining a proper environment for micro-organisms on which the fertility of the soil so largely depends; and the beneficial effect is naturally predominant in forms that are either non-motile or that pass through a non-motile stage.

We may also apply the above consideration to the question whether there is any appreciable upward movement of water to the surface from lower depths where the strata are saturated—*i.e.*, the ground water table. Diverse views have been expressed on this point, estimates of the maximum distance over which water can thus be raised varying from hundreds of yards to a few feet. Although the numerous laboratory experiments that have been made have suggested the lower value as correct, yet there has always remained the possibility that the values might be higher under field conditions. Results obtained in 1921, with a special form of soil tanks, would seem to dispose of this doubt. The tanks were cylindrical in form, 6 ft. deep by 2 ft. 6 in. in diameter, closed at the bottom and the top edge was at ground level. A thin layer of coarse gravel was spread over the bottom of each cylinder and the soil was carefully filled in. A vertical pipe 2 in. in diameter passed through the soil to the gravel layer, and by the aid of a long ruler the level of the water in this pipe could be measured at any time. The cylinders were left for some years for the contents to settle down before systematic readings were taken. In the winter of 1920-21, the soil was, as usual, saturated. It gradually dried out with the advent of spring, and the water level in the indicator pipe receded. Daily measurements of this change were made over the whole of the year. Over the drought period the level in the cylinder containing Rothamsted soil fell rapidly to about 28 in. below the surface in 30 days. Then the rate of fall diminished rapidly, and the water level had only receded a further 10 in. when the weather finally broke some 80 days later. The initial saturation of the soil and the sustained evaporation conditions of the drought were both favourable to a state of affairs in which the water raising power of the soil should show to advantage. The low values actually found demonstrate that especially in normal years, the moisture content of the top soil is not markedly affected by supply from below either by capillary action or by a movement of the water films over the soil grains.

This conclusion emphasises the importance of the moisture present in the top two or three feet of soil. If it is not appreciably added to from underground sources, but is dependent for additions on the rainfall, the danger to crops of drought periods and of

extensive evaporation from the soil surface is obvious. In practice we find, even in this country with its adequate and well-distributed rainfall, a vital necessity to adapt our cultivation operations so that the store of water in the top soil may be conserved.

The existence of a considerable volume of pore space in soils unoccupied by water raises the interesting question of the humidity of the soil air. Measurements on the vapour pressure of soil at different moisture contents indicate that the full value is attained at quite low moisture contents which are in fact below the optimum value for crop growth. For the Rothamsted soil the values lie between 6 per cent. and 8 per cent. depending on the amount of clay and organic matter present. Hence over the normal range of moisture content for satisfactory crop growth, the soil air is in contact with what is virtually a free water surface. Simple calculations show that the effective area of this water film stretched over the innumerable soil particles is very large ; the individual pore spaces, although constituting in the aggregate some 30 per cent. to 40 per cent. of the soil volume, are very minute. Hence the soil air is practically always saturated with water vapour except in the top dried mulch. Alternations of barometer pressure and temperature changes promote an exchange of soil air and atmospheric air, but the approximate depth to which this takes place is still a matter of dispute. The above considerations, however, show that atmospheric air entering the soil is rapidly saturated with water vapour.

This brief review of certain borderline aspects of meteorology and soil physics has by no means covered even the main points of interest. Nothing at all has been said of the colloidal properties of soil and their effect on soil moisture relationships. This study is perhaps the fundamental characteristic of modern soil physics, and its importance can be gauged from the fact that practically all the matters discussed in the present article strictly apply not to soil but to moist sand. The water relationships of the latter material are comparatively simple, but they serve to illustrate the broad effects that occur in soil, and for purposes of simple presentation they have the advantage of freedom from the complex factors introduced when colloidal materials such as clay and organic matter have to be taken into account.

Meteorological Results of the Oxford University Arctic Expedition

THE Oxford University Arctic Expedition, under the leadership of Mr. George Binney, spent the summer of 1924 in Spitsbergen. Meteorological observations were taken on board the *Polar Bjorn* and *Oiland* in Spitsbergen waters and for six weeks at the head-

quarters of the expedition at Liefde Bay (79°42′ N, 13°48′ E) on the north coast. An aeroplane was employed for aerial surveying, and some upper air temperatures were obtained during the flights. The weather was regarded especially from the aviator's point of view throughout, and this constitutes the chief value of the record.

During August, observations at Liefde Bay are nearly complete at 13 h. and 18 h. G.M.T., and these give a mean pressure of 1008·3 mb. During the same month, the mean pressure at Green Harbour (78°2′ N) was 1009·1 mb. (provisional value), so that the average gradient was small. The winds were generally light and only one gale was recorded ; the most noticeable feature was the suddenness of the changes of direction and strength, winds of moderate strength frequently occurring between the times of observation. The mean temperature of 38° F. was about 3° F. below that at Green Harbour. The highest maximum at Liefde Bay was 50° F. and the lowest minimum 29° F., but an exceptional temperature of 58° F. was recorded on the *Oiland* in Treurenberg Bay. The sun was above the horizon continuously and there seemed to be more sunshine at " night " than during the day, but the thermograms usually show some indication of the diurnal variation of temperature, and this was well-marked on 10 days out of 46. There were 12 days of snow, but the total precipitation, some of which fell as rain, was only 18 mm. (0·72 in.). The weather was humid and cloudy and it was difficult to keep clothes dry.

The most valuable observations relate to the visibility, which was extraordinarily good except when interfered with by low cloud. At Liefde Bay, 66 per cent. of the observations in July and 44 per cent. of those in August gave a visibility exceeding 30 km., and on no occasion did the visibility fall below 1,000 metres. Mr. F. Tymms, the meteorologist of the expedition, continues : " There seems reason to believe that conditions differ widely between the west and north coasts. On the west coast definite fog was experienced, but on the north coast, though banks of fog, which appeared dense from a distance, were very frequently experienced, they were very patchy, never very high and never produced really low visibility . . . . I am certain that these fogs would prove no obstacle to aviation, because even if it were desired to land, clear areas could be found. These fog banks were always associated with a N to E wind, and were almost the invariable accompaniments of such a wind." During the six weeks at Liefde Bay, low cloud (below 1,500 ft.) was present during about 40 per cent. of the observations and often obscured distant high points. On the west coast dense fog (visibility 50 metres) was occasionally experienced. In

Hinlopen Strait to the north-east, the visibility was not generally so good as on the north coast.

The state of the ground, assuming that a level landing ground could be found, was generally unfit for the landing of aircraft. On July 9th, there was much drift snow and the remainder of the ground was very soft and muddy, and in spite of the good drainage qualities of the soil it was not until August 6th that the ground could be described as dry; most of the neighbourhood was again covered with snow by August 27th.

Unfortunately, it was not possible to carry out the full programme of meteorological observations by aeroplane, but enough were obtained to show that the vertical temperature gradient was slight. The following readings represent an ascent in an almost cloudless sky on August 30th:—

Ground 35° F.	3,000 feet 29° F.
1,000 feet 37° F.	3,800 feet 28° F.
2,000 feet 34° F.	8,000 feet 27° F.

The meteorological conditions during the summer of 1924, appear to have been about normal for the time of year, and the information collected by the expedition will be of considerable value for future aviation in the neighbourhood of Spitsbergen.

Correspondence

To the Editor, *The Meteorological Magazine*

Crepuscular Rays

AT 9.10 p.m. (Summer Time) this evening while the sun was still shining and the moon was high in a clear sky to the south-west, I happened to glance towards the south-east where there were several white and pink fleecy clouds. I noticed a dark band starting from the horizon and stretching upwards. The band was not vertical but inclined about 30° from the vertical and if produced would apparently reach the sun. It was very conspicuous against the background of light cloud and was even observable against the blue sky higher up. I can best describe it as a "reversal" of a sun pillar, except that it was not vertical.

After about five minutes, the clouds became darker, as the sun disappeared and the phenomenon gradually died out.

I should be interested to know whether this phenomenon has been observed by others.

W. A. KNIGHT.

Sexey's School, Bruton, Somerset. June 28th, 1925.

Meteoric Fireballs

YOUR interesting remarks* on detonating fireballs and the necessity for acquiring multiple observations will, I hope, cause observers to give special attention to the subject. The importance of correctly deriving the velocity of sound in the upper atmosphere is admitted and the problem is one not very difficult to solve. In past years the available records have been inadequate to meet requirements. Data were often inaccurate and incomplete and deductions more or less doubtful were the only ones derivable from them. If observers know exactly what details are to be noted in connexion with such phenomena they will no doubt strive to procure them, and thus effectively aid investigation.

Detonating meteors of large size are really more abundant than is supposed, but many of them pass without being fully described and are lost to science. Eight fireballs were reported to me during the last quarter, as follows:—

Date.	Time (G.M.T.).	Brightness.	Place of Observation.
1925.	h. m.		
March 22nd ..	21 35	¼ Moon	Oxley, Yorks.
April 4th ..	19 50	Greater than Venus	Croydon, Surrey.
12th ..	21 40	= Moon	S.W. England.
16th ..	1 15	= Moon	,,
20th ..	23 38	5 times Venus	Ashby, Linc.
June 4th ..	16 10	= Moon	Cornwall & S. Wales.
5th ..	21 55	= Moon	S.W. England.
14th ..	1 30	= Venus	Bristol.

Three of the above objects were detonating, and in five cases out of the eight it was found impossible to compute the real paths owing to the lack of necessary observations. With regard to the instances in which the meteors detonated the time intervals stated to have passed between the flashes and the explosions were merely rough estimates which differed materially and could not be harmonized.

W. F. DENNING.

Horfield, Bristol. July 22nd, 1925.

* See *Meteorological Magazine* 60 (1925), 145.

Red Lightning

In May, 1867, the first 10 days saw a spell of phenomenal heat. On the 10th a short sharp thunderstorm broke over Cambridge and district just before noon with serious casualties from lightning. This first storm soon cleared off; but in the late afternoon as I walked back into Cambridge from Trumpington, it was thundering loudly and it appeared to my eyes that horizontal flashes, beyond counting, of dull red lightning were darting across the street at about 6 feet from the ground. One could have thought that these flashes were being fired from the ground floor windows on either side. It continued to thunder overhead, but independently of the lightning. It was a terrifying experience. I hurried to my rooms at Emmanuel College, just in time to escape a heavy downpour of rain and hail. The storm lasted well into the night, and made a big flood in the Cam. Details of this storm are given in *British Rainfall*, 1867, p. 59. The rain is given as 1·15 in. at Brook House. No mention is made of red lightning, but in other respects that account agrees closely. The dull red flashes were seen in broad daylight about 6.30 p.m., not against the sky, but against the houses, and were devoid of any illuminating brightness.

On April 30th, 1875, I had a like experience with very different surroundings. I was then living at Patras in Greece, and had come, in weather unusually wet for that time of year, over the passes of Mt. Erymanthus to Olympia. We crossed almost without notice two small gullies, quite close together, nearly if not quite dry. The morning had been very fine, but now at about noon clouds gathered fast, and a violent thunderstorm was soon raging with very heavy rain and hail. It soon became clear that the streams ahead would be quite impassable. There was nothing for it but to return. Arrived at the first of the aforesaid gullies we found a dangerous looking torrent through which we hurried. But on coming to the second gully we found it quite hopeless to cross it. There we had to wait in the pouring rain and hail, the thunder echoing from the steep rocky sides of the narrow valley, and again dull red horizontal flashes appeared to be darting across the valley at a low level, countless in number, and seemingly independent of the thunder overhead, and were seen against a background of pines and rocks. After perhaps an hour's waiting the sky began to clear, the sun soon shone brightly, the torrent abated as fast as it had risen, and we returned through Krestena, where there was loud lamentation because of the destruction in the vineyards by the hail. The high proportion of hail to rain is shown by the temperature of the torrent in the gully, which was 36° though it is but 300 ft. above sea level. The next day was gloriously fine.

On Sunday, May 13th, 1906, there was a notable thunderstorm in Somerset. At Melles and also at Downside 3 in. of rain fell (vide *British Rainfall*). At North Cadbury the fall was 1·19 in. between 4.30 p.m. and 11 p.m. Thunder and lightning were incessant from 3.30 till 11; the bulk of the rain fell between 4.30 and 6. Evensong began in the church at 6 with a sadly depleted congregation, and from the pulpit at 6.45 I had my third experience of red lightning, for I could see through the windows dull red horizontal flashes which seemed to be darting about the churchyard; and later till it was dusk the whole country-side seemed to be full of this dull red lightning, apparently independent of the thunder. From time to time there were bright flashes of ordinary colour almost simultaneous with the thunder, but the non-luminous character of the red lightning was very noticeable.

It will be observed that in each of these three cases of red lightning it was broad daylight, but even so the non-luminous character of these horizontal flashings near the ground was remarkable. I can but record from notes made at the time what I thought I saw. Can any of your readers throw any light on the real nature of this, I suppose, rare phenomenon, or say whether it was as dangerous as it looked?

H. A. BOYS.

Spring Hill, S. Mary Bourne, Andover. July 13th, 1925.

Waterspouts observed at the Isle of Man

I WITNESSED two waterspouts from the promenade here this evening. The first one commenced to develop at 6.25 p.m., B.S.T., at a spot situated roughly 10 miles south magnetic from Port St. Mary breakwater light, and travelled at a rapid rate in an easterly direction, finally disappearing at 6.35 p.m., when it bore roughly south-east magnetic from the above-mentioned lighthouse. The second one started at 6.40 p.m. at a spot situated about midway between the starting and finishing points of the first one. It travelled in the same direction and at about the same rate as the first one, finally disappearing in about the same position at 6.45 p.m.

The weather at the time was sultry with a suggestion of rain; the clouds in the region of the waterspout were very heavy and lowering with jagged edges; the sea was very smooth and the wind NW light breeze. The portions of the spouts proceeding from the clouds were more defined than those proceeding upward, and the tips in each instance appeared to revolve with a pendulum motion, as though suspended by the base in the clouds.

W. H. TOTTEY.

The Quay, Port St. Mary, Isle of Man. July 26th, 1925.

Mammato-Cumulus Cloud at Cranwell, Lincolnshire

As the result of an almost continuous watch kept upon the face of the sky at Cranwell, Lincolnshire, 12 examples of mammato-cumulus cloud were observed during the period January 1st, 1920, to July 10th, 1925. In view of the rarity of this particular cloud, some analysis of the meteorological conditions prevailing at, or near the times of occurrence of the 12 appearances, may not be without interest.

The surface winds prevailing at the actual times of occurrence were as follows :—

Between	W and N	(inclusive)	on 7	occasion(s).
,,	N and E	,,	0	,,
,,	E and S	,,	1	,,
,,	S and W	,,	4	,,
	CALM		1	,,

The fact that, of the 12 cases, only one occurred with any easterly component in the surface winds seems noteworthy.

Of the 12 days upon which the phenomenon was observed, precipitation occurred on 10 days. On 3 days only it fell at the actual time of occurrence of the cloud. On only one of the 12 days did thunderstorms actually occur at Cranwell ; but the Daily Weather Reports issued by the Meteorological Office, show that on 5 of the days storms occurred in either the midland, eastern or south-eastern districts of England, this number including the 1 case in which a storm was actually over Cranwell. On 7 of the 12 days cumulo-nimbus cloud was observed at some time or other. On 2 occasions it both preceded and followed the occurrence of the mammato-cumulus ; on 2 it preceded only ; and on 3 it followed only.

In 2 cases line squalls occurred within the hour preceding the noting of the mammato-cumulus cloud. In no other case did line squalls occur at any time during the day of the appearance of mammilation.

With regard to the map conditions prevailing, 8 of the 12 cases could definitely be associated with the rear of depressions, 3 with the fronts of depressions, and 1 with a col.

W. H. PICK.
G. A. WRIGHT.

R.A.F. (Cadet) College, Cranwell, Lincolnshire. 10th July, 1925.

Rain from a Blue Sky

I WAS surprised on July 18th at 15h. 16m. G.M.T. to find a shower falling from what to all appearances was a perfectly blue sky. I was at Boveysand ($2\frac{1}{2}$ miles from Cattewater) when

large drops of rain caused me to look up and observe that the sky was clear with the exception of cumulo-nimbus on the horizon and a small amount of alto-cumulus some distance ahead and receding towards the east. The latter was at a height of, approximately, 12,000 ft. Only about twenty yards of the ground, which was cemented concrete, showed the track of the shower. It was, then, a slight very short and very local fall of rain.

Weather conditions favoured the occurrence of local showers and some did fall in the forenoon but with the one exception noted above no precipitation took place in the Boveysand or Plymouth districts during the whole afternoon or evening, all the orthodox rain clouds remaining on the horizon. Up to 6,000 ft. at least a west-south-west sea-breeze prevailed. This would bring a certain amount of moisture-laden air, but readings at Cattewater show the relative humidity to have been between 60 per cent. and 70 per cent. with a temperature of a little over 60° F. By 15h. the sea would most likely have become warmer than the land; yet the westerly wind persisted. It has been noticed on several occasions that winds behave curiously along the cliffs at Boveysand. For instance, a fire lighted on the southern end of the cliff in an afternoon gives a volume of smoke which has been observed to drift, in a south-west wind, over the eastern slope and disappear and to appear again a short distance away drifting over the western cliff, even though the wind persisted from southwest. It is suggested that such conditions may have existed at a greater height on the 18th, and that the warmer more humid sea air was condensed by the comparatively cooler air which thus "overflowed" as it were from the land, causing the very local shower on the western side of the cliff, the cloud being too thin to be visible.

T. H. APPLEGATE.

Cattewater, Plymouth, July 24th, 1925.

Corrigendum

WE regret that the authority for the data for Johannesburg, which appears regularly in the "Climatological Table for the British Empire," was erroneously stated, on p. 155 of the *Meteorological Magazine* for July, to be the Chief Meteorologist, Pretoria. The data are supplied regularly by the Union Astronomer, Union Observatory, Johannesburg.

NOTES AND QUERIES

A New Form of Nephoscope

AN interesting description has recently been received of a new and inexpensive type of nephoscope designed by Major Agostinho, of the Azores Meteorological Service.

The principle of the instrument is similar to that of the Hill mirror, in so far as observations are made on the reflection of a portion of cloud.

The apparatus, in its simplest form, consists of a small wooden box, the bottom of which is covered by a plane mirror, 22 cm. square, and the lid of which is a sheet of glass parallel to the mirror and 4 cm. above it. When in use, a mark is made in the centre of the glass, and the reflection of this mark in the mirror aligned with the image of the portion of cloud under observation. The point at which the line joining these two images cuts the glass is marked by an ink spot. After a definite time, say one minute, has elapsed, and the cloud has moved through a certain distance, another observation is taken, and a similar mark made. If the distance between the two points is measured on the surface of the glass, the velocity-height-ratio of the cloud may be easily calculated from considerations of the dimensions of the instrument. The direction of motion is, of course, parallel with the line joining the two points.

Vertical Currents

THE results of pilot balloon ascents made on June 4th, 1925, at Larkhill (Salisbury Plain), appear to confirm the occurrence of descending currents in the lowest kilometre of the atmosphere in an anticyclonic area. It will be seen from the table that the descending currents presisted throughout the greater part of the day, extending roughly from 3,000 feet to the ground and that at times they were as strong as 6·3 feet per second. The sky was practically cloudless, occasional small amounts of fracto-cumulus being observed towards the horizon so that the effects cannot be ascribed to descending currents associated with the gaps between cumulus clouds. The effects were not due to contour, the ground being generally slightly higher to the north and north-west of this station. Unfortunately owing to the light winds which were prevalent on this day no reliable estimates of ascending or descending currents are available from other pilot balloon stations. On the preceding day there were ascending currents of small amount up to 1,000 feet but from 1,000 to 3,000 feet descending currents of one to four feet per second

were observed with a fairly steady wind from west-southwest. On June 5th the centre of the anticyclone had moved from the English Channel to Denmark, and the descending currents were neither strong nor persistent.

PILOT BALLOON ASCENTS (TAIL METHOD), JUNE 4TH, 1925

Time	10h. 45m. G.M.T.				11h. G.M.T.				12h. 40m. G.M.T.			
	Height	Wind Direc-tion	Speed	Vertical current	Height	Wind Direc-tion	Speed	Vertical current	Height	Wind Direc-tion	Speed	Vertical current
(min.)	(ft.)	°	(ft/s.)	(ft/s.)	(ft.)	°	(ft/s.)	(ft/s.)	(ft.)	°	(ft/s.)	(ft/s.)
0	Surface	175	4	—	Surface	219	11	—	Surface	190	9	—
1	500	194	7	0	450	204	7	—0·8	350	181	12	—2·5
2	800	205	9	—3·3	700	157	11	—4·2	626	164	13	—3·7
3	1,190	203	11	—1·8	820	159	11	—6·3	990	169	13	—2·3
4	1,600	198	8	—1·5	1,000	164	12	—5·3	1,380	151	12	—1·8
5	2,095	184	11	—0·1	1,400	164	12	—1·7	1,650	149	10	—3·8
6	2,600	172	12	0·1	1,940	173	13	0·7	2,000	172	12	—2·5
7					2,350	167	15	—1·5	2,290	170	19	—3·5
8					3,000	139	18	2·5	2,550	163	17	—4·0
9					3,510	139	18	0·2	2,910	156	16	—2·3
10					4,000	145	20	—0·2	3,610	156	16	3·3
11					4,460	152	25	—0·7	4,230	166	21	2·0
12					5,030	148	22	1·2	4,760	163	23	0·5

R.P. 3.

The Climates of Paris and London

IN a recently published analysis of the records of rainfall at Paris for the last 50 years,* Dr. Louis Besson has made use of the *British Rainfall* classification of "rain spells" and "wet spells."† He finds that the number of rain spells in 100 years at Paris was 10 but that wet spells are unknown. For comparison, Besson quotes the figures for 100 stations given in *British Rainfall*, 1921, thereby illustrating the difference between the climates of Paris alone and the whole of the British Isles. It is perhaps more appropriate to bring the statistics for a single London station for a long run of years into the comparison. In *British Rainfall*, 1922 (p. 9), the results of an analysis of the Camden Square figures for the 35 years 1881-1915 are set out as well as those for a wet station, Crossmolina, in the north-west of Ireland. At Camden Square there were 4 rain spells but no wet spells in the 35 years. On the evidence available there is nothing to choose between Paris and London. Some details

* Ann. Serv. Tech. Hygiène Paris, Vol. 5, Paris, 1924.

† *A Rain Spell* is a period of at least 15 days to each of which is credited ·01 in. or more.

A Wet Spell is a period of at least 15 days to each of which is credited ·04 in. or more.

An Absolute Drought is a period of at least 15 days to none of which is credited ·01 in. of rain or more.

A Partial Drought is a period of 29 days, the mean rainfall of which does not exceed ·01 in.

A Dry Spell is a period of at least 15 days to none of which is credited ·04 in. of rain or more.

are given in the table below, based on 50 years' observations at Paris (1873-1922) and 35 at Camden Square (1881-1915).

	Number per annum.	
	Paris.	Camden Square.
Rain days	156	162
Wet days	109	115
Rain Spells	·10	·11
Wet Spells	0	0
Absolute Droughts ..	1·50	1·23
Partial Droughts ..	1·46	1·00
Dry Spells	2·82	2·89
Rainfall (inches) ..	22·8	24·5

From the other figures which have been transcribed here it appears there is a little more risk of absolute drought at Paris than in London. This may, however, be mostly a question of rain-gauge exposure. The risk of a " dry spell " is the same in the two cities.

Reviews

An Introduction to Fluid Motion. By W. N. Bond, B.A., D.Sc., F.Inst.P. 8vo., $7\frac{1}{4} \times 4\frac{3}{4}$, pp. 94. London: Edward Arnold & Co., 1925. Price 5s.

THIS little book aims at presenting " An introduction and a guide to one embarking on the advanced study of fluid motion." It is divided into five Chapters: I. Outline of the General Principles; II. Fluid Motion between Solid Boundaries; III. Surface Waves, and Motion in Channels and over Weirs; IV. The Motion of a Body through Fluid; V. The effect of Compressibility of the Fluid.

Under the heading of General Principles, the author discusses compressibility, viscosity, streamlines, turbulence, flow through orifices, and considerations of momentum. The second chapter contains an interesting discussion of manometers, an outline of the method of dimensions, which is freely used throughout the book, and some discussion of turbulent motion. The general nature of the remaining chapters can be gathered from their titles.

Throughout the book there are frequent references to experimental work, but the author has avoided burdening his work with too many details of laboratory technique, and has also avoided the opposite error of burdening the book with too much mathematical analysis. The topics discussed have been graded with much discretion, so that the earlier topics involve only the simple considerations, the difficulties which are bound up with viscosity, compressibility, etc., being discussed later.

The book should appeal to a wide public, and can be read with much profit by the meteorologist who wishes to attack his subject from the dynamical aspect. To those like the present writer, whose memory of Lamb's Hydrodynamics has become dulled through lack of use, this little book provides a most stimulating refresher.

It is a striking fact that hydrodynamics, which for a generation appeared to have attained something approaching finality, has, under the impetus of the development of aeronautics, attained a new lease of life, and some very striking new results have been described by G. I. Taylor and others in recent papers. To the student who wishes to read these later researches, Dr. Bond's book provides a most helpful introduction. There are frequent references to original papers throughout the book.

D. BRUNT.

Regenval in het Noordelijk deel van Sumatra's Oostkust. By Dr. J. Boerema. Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia. Verh. No. 11. 8vo., 11×7, pp. IV+16 (Dutch)+15 (English). *Illus.* Albrecht & Co., Weltevreden. 1923.

THIS publication deals with the rainfall at some 300 stations along the east coast of northern Sumatra. The area extends over about 300 miles of coast and stretches about 100 miles inland. Statistics are given of the average annual and monthly rainfall, and of the number of rain-days, together with rainfall charts on a scale of about 27 miles to 1 in. The average utilised is that for the 20 years, 1901 to 1920. In order to obtain averages for stations with short records the following procedure was adopted. Means were evaluated for each of the groups of 5 years 1901 to 1905, 1906 to 1910, 1911 to 1915, and 1916 to 1920. Each of the four means was expressed as a percentage of the 20 year average and four maps constructed. These maps were utilised in correcting short records covering the 5, 10 or 15 years to the mean of 20 years. This was practically the same method as that employed by Dr. H. R. Mill in the Rainfall of the Exe Valley,* where data were not numerous. In working up the monthly data use was made of isomeric maps (*i.e.*, maps showing the average monthly fall as a percentage of the average). This method has recently been used with advantage in this country.†

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* *London Geo. J.* 34 (1909), 630.

† A new Method of Constructing Average Monthly Rainfall Maps. By M. de Carle S. Salter, London. *Q.J.R. Meteor. Soc.*, 47 (1921), 101.

The area under consideration lies between latitude 2° and 4° N, and the maximum rainfall takes place after the passage of the sun through the zenith at the end of March and the middle of September. The rainiest season is in October and November with a secondary maximum falling in April and May. Maps are given showing the months of maximum, minimum, secondary maximum and secondary minimum of rainfall. It is interesting to note that along a line drawn parallel to the coast about 40 miles inland the two minima have an equal value. To the west of this line, the June minimum is the primary one, while to the east it is secondary to the February minimum. The yearly distribution of rainfall was inserted graphically on a chart and those stations with similar distributions were assembled into one group. In all, 17 groups were isolated. For each group the means of the average monthly rainfall of all stations were evaluated and the final values for each class were indicated graphically on a map. This map, which is reproduced in the paper, also indicates the limits of each zone and forms a valuable contribution to the climatology of Sumatra. The yearly range of rainfall along the east coast of Sumatra is small, long periods of no rain such as occur at Java being unknown. Statistics are given of the maximum period of no rain at 7 stations for each month of the year. These figures are much more uniform than would be the case in the British Isles where such periods are rarer in the winter months than in the spring and summer. The paper contains a valuable series of maps and tables.

J.G.

News in Brief

We regret to announce the death on August 15th of Captain R. C. Warden, who has represented the Board of Trade on the Meteorological Committee since 1922.

During a thunderstorm at Cattewater, Plymouth, on August 6th, 26 mm. (1.02 in.) of rain fell in 2 hours, the extreme rate of fall being 4 mm. (.16 in.) in 3 minutes, *i.e.*, 80 mm. (3.20 in.) per hour.

We learn from Dr. Friedmann that a new Geophysical Observatory forming a local branch of the Geophysical Central Observatory at Leningrad was opened at Jakutsk (62°01′ N, 129°43′ E from Greenwich) on July 12th, 1925. At the present time the work of the new observatory is confined to meteorology and aerology but it is hoped that in the course of the next few years the observatory will be equipped for actinometrical, optical and magnetic observations.

The Royal Meteorological Society has awarded the Howard Prize for 1925 to Cadet H. W. Barnett of S.A.T.S. *General Botha*, South Africa, for the best essay on " Icebergs : their Distribution and Drift."

We learn with regret of the death on Saturday, August 29th, of Mr. F. J. Brodie, who retired in 1919 from the staff of the Meteorological Office after 50 years' service.

The Weather of August, 1925

DURING the first part of the month the weather was generally unsettled ; pressure was low off our western coasts and secondaries passed across the country. Rain fell almost daily in some places ; moderately heavy falls were recorded, among the largest being 31 mm. (1·22 in.) at Falmouth and Plymouth on the 5th, 34 mm. (1·34 in.) at Manchester on the 10th, 39 mm. (1·54 in.) at Blacksod Point on the 11th, 38 mm. (1·50 in.) at Eskdalemuir on the 12th. Thunderstorms occurred in many parts of the country on the 1st, 5th and 6th, and again on the 10th and 11th. There were bright periods during which good sunshine records were obtained.

On the 13th, an anticyclone began to spread eastward over the British Isles and the weather improved. From the 14th to the 17th there was very little rain, and on the 15th, 16th and 17th it was generally sunny and maximum temperatures of 80° F. and above were recorded at a few stations.

On the 18th, depressions over southern England and south-west Iceland displaced the anticyclone and renewed the unsettled weather ; thunderstorms occurred over the country, and rainfall was again rather heavy, especially in the south on the 23rd, when Calshot recorded 44 mm. (1·73 in.) and Guernsey 38 mm. (1·50 in.).

Towards the end of the month the Azores anticyclones spread north-eastward, causing fairer weather in the more southerly districts.

Pressure was slightly above normal at North Cape and Spitsbergen, and also over Spain and the Mediterranean, and slightly below normal over central Europe and Sweden. Over the British Isles the pressure deviations were very small. Temperature and rainfall were about normal, except in Spitsbergen, which was unusually warm. In Sweden, temperature averaged 2° F. above normal, the extremes ranging from 81° F. to 29° F. ; rainfall was about 20 mm. above normal in the north, but below in the remaining districts.

The early part of the month was marked by very stormy

weather over the central part of Europe. Damage by wind and rain was done to crops in Austria and Hungary at the beginning of the month; trees were uprooted in Paris by a gale accompanied by a heavy downpour; snowstorms in the Alps caused the deaths of five climbers.

On the 9th and 10th, severe thunderstorms occurred in northern Europe; much damage was done in Denmark and north Germany, several persons being killed by lightning. Near Uetersen and Neuendeich, a cloudburst accompanied by heavy hail wrecked some houses. A violent tornado visited Holland on the night of the 10th. Coming from the direction of Roosendal on the Belgian frontier it swept over the provinces of North Brabant (where, in the villages of Zeeland and Langenboom, three people were killed and others severely wounded) and Gelderland. The greatest damage was done at Borculo, whence the storm passed over Zutphen and Meppel in the province of Overyssel, finally drifting towards the North Sea near Groningen with diminished intensity. At Borculo not one house remained intact, and out of the 5,000 inhabitants, 2,000 were rendered homeless. The storm exercised an upward suction, the roofs of many houses being lifted bodily and deposited on the heath several hundred yards away.

After a period of good weather in the middle of the month, unsettled conditions recurred about the 21st and heavy rain fell in many districts, especially in Switzerland. By the 27th, the Danube, the Rhone and the Isar had risen 2 ft.

On the 27th, extremely heavy rain followed by a severe thunderstorm caused floods and landslides in Tokyo and Yokohama. Thousands of houses were partly submerged and 18 lives were lost.

The special message from Brazil states that rain was scarce generally; it was 33 mm. below normal in the north, 25 mm. in the centre, and 49 mm. in the south. In Rio de Janeiro for the first time since records have been taken no rain fell at all in August. Anticyclonic conditions persisted, the abnormal position of the Atlantic anticyclone causing the rapid absorption of the centres of depressions coming from the Pacific. Excepting the wheat in the extreme south the crops are generally affected by the continued deficiency of rainfall. At Rio de Janeiro the pressure was 0·4 mb. above normal and the temperature 2·5° F. above normal.

Rainfall August, 1925—General Distribution

England and Wales ..	101	per cent. of the average 1881-1915.
Scotland	81	
Ireland	69	
British Isles	89	

Rainfall: August, 1925: England and Wales

CO.	STATION.	In.	mm.	Per-cent. of Av.	CO.	STATION.	In.	mm.	Per-cent. of Av.
Lond.	Camden Square.....	2·71	69	123	*War.*	Birmingham, Edgbaston	2·95	75	109
Sur .	Reigate, Hartswood...	2·74	70	119	*Leics*	Thornton Reservoir ..	1·87	47	67
Kent.	Tenterden, View Tower	1·23	31	54	,, .	Belvoir Castle.....	1·45	37	55
,, .	Folkestone, Boro. San.	1·20	30	...	*Rut .*	Ridlington.....	2·10	53	...
,, .	Broadstairs, St. Peter's	1·34	34	65	*Linc.*	Boston, Skirbeck	1·44	37	60
,, .	Sevenoaks, Speldhurst.	2·05	52	...	,, .	Lincoln, Sessions House	1·35	34	55
Sus .	Patching Farm.....	3·82	97	152	,, .	Skegness, Estate Office.	1·68	43	69
,, .	Brighton, Old Steyne .	2·62	67	118	,, .	Louth, Westgate	·91	23	33
,, .	Tottingworth Park....	2·30	58	85	,, .	Brigg	1·83	47	66
Hants	Ventnor, Roy. Nat. Hos.	5·71	145	287	*Notts.*	Worksop, Hodsock....	1·76	45	72
,, .	Fordingbridge, Oaklnds	3·34	85	127	*Derby*	Mickleover, Clyde Ho..	3·26	83	120
,, .	Ovington Rectory	3·20	81	118	,,	Buxton, Devon. Hos...	4·52	115	103
,, .	Sherborne St. John Rec.	3·17	81	131	*Ches.*	Runcorn, Weston Pt...	3·19	81	89
Berks	Wellington College...	3·12	79	134	,, ..	Nantwich, Dorfold Hall	3·58	91	...
,, .	Newbury, Greenham..	2·31	59	88	*Lancs*	Manchester, Whit. Pk.	3·94	100	114
Herts.	Bennington House....	3·11	79	...	,, ..	Stonyhurst College....	3·98	101	79
Bucks	High Wycombe	4·03	102	174	,, ..	Southport, Hesketh...	3·58	91	103
Oxf..	Oxford, Mag. College..	2·15	55	96	,, ..	Lancaster, Strathspey.	3·54	90	...
Nor .	Pitsford, Sedgebrook..	1·59	40	66	*Yorks*	Sedbergh, Akay	5·06	129	90
,, .	Eye, Northolm.....	1·84	47	...	,, .	Wath-upon-Dearne ...	2·21	56	92
Beds.	Woburn, Crawley Mill.	2·33	59	104	,, .	Bradford, Lister Pk...	3·64	93	97
Cam.	Cambridge, Bot. Gdns.	1·87	47	80	,, .	Wetherby, Ribston H..	2·36	60	86
Essex	Chelmsford, County Lab	2·93	74	135	,, .	Hull, Pearson Park ...	1·80	46	62
,, .	Lexden, Hill House...	2·17	55	...	,, .	Holme-on-Spalding ...	2·93	74	...
Suff .	Hawkedon Rectory ...	3·17	81	122	,, .	West Witton, Ivy Ho..	3·15	80	...
,, .	Haughley House.....	2·67	68	...	,, .	Felixkirk, Mt. St. John	2·48	63	87
Norf.	Beccles, Geldeston....	2·81	71	130	,, .	Pickering, Hungate ...	3·88	99	...
,, .	Norwich, Eaton	2·36	60	100	,, .	Scarborough.....	4·02	102	145
,, .	Blakeney	2·73	69	121	,, .	Middlesbrough	3·14	80	115
,, .	Swaffham	2·69	68	104	,, .	Baldersdale, Hury Res.	2·93	74	83
Wilts.	Devizes, Highclere....	2·03	52	70	*Durh.*	Ushaw College	3·31	84	114
,, .	Bishops Cannings	2·90	74	94	*Nor .*	Newcastle, Town Moor.	2·37	60	81
Dor .	Evershot, Melbury Ho.	3·28	83	104	,, .	Bellingham, Highgreen	3·54	90	...
,, .	Weymouth, Westham..	...	...	...	,, .	Lilburn Tower Gdns...	2·12	54	...
,, .	Shaftesbury, Abbey Ho.	2·65	67	91	*Cumb*	Geltsdale.....	4·35	111	...
Devon	Plymouth, The Hoe...	4·35	111	146	,, .	Carlisle, Scaleby Hall .	2·78	71	68
,, .	Polapit Tamar	3·26	83	103	,, .	Seathwaite M.....	11·38	289	98
,, .	Ashburton, Druid Ho..	4·70	119	126	*Glam.*	Cardiff, Ely P. Stn.....	6·26	159	145
,, .	Cullompton	2·84	72	93	,, .	Treherbert, Tynywaun	7·89	200	...
,, .	Sidmouth, Sidmount ..	2·78	71	99	*Carm*	Carmarthen Friary....	4·81	122	104
,, .	Filleigh, Castle Hill ...	4·22	107	...	,, .	Llanwrda, Dolaucothy.	6·50	165	118
,, .	Barnstaple, N. Dev. Ath.	4·53	115	137	*Pemb*	Haverfordwest, School	4·40	112	...
Corn.	Redruth, Trewirgie ...	3·43	87	100	*Card.*	Gogerddan.....	6·58	167	135
,, .	Penzance, Morrab Gdn.	3·59	91	113	,, .	Cardigan, County Sch. .	2·72	69	...
,, .	St. Austell, Trevarna..	3·28	83	91	*Brec .*	Crickhowell, Talymaes	5·50	140	...
Soms	Chewton Mendip	4·38	111	98	*Rad .*	Birm. W. W. Tyrmynydd	4·92	125	91
,, .	Street, Hind Hayes ...	3·56	90	...	*Mont.*	Lake Vyrnwy	4·74	120	92
Glos..	Clifton College	2·86	73	82	*Denb.*	Llangynhafal	3·11	79	...
,, .	Cirencester	4·42	112	144	*Mer .*	Dolgelly, Bryntirion..	7·86	200	140
Here .	Ross, Birchlea	2·93	74	115	*Carn.*	Llandudno	1·76	45	58
,, .	Ledbury, Underdown.	2·22	56	85	,, .	Snowdon, L. Llyday 9	16·43	417	...
Salop	Church Stretton.....	3·18	81	98	*Ang .*	Holyhead, Salt Island.	2·68	68	84
,, .	Shifnal, Hatton Grange	2·40	61	85	,, .	Lligwy	2·78	71	...
Staff.	Tean, The Heath Ho...	3·06	78	88	*Isle of Man*				
Worc.	Ombersley, Holt Lock.	1·69	43	63		Douglas, Boro' Cem...	2·37	60	61
,, .	Blockley, Upton Wold.	2·51	64	85	*Guernsey*				
War.	Farnborough.....	1·73	44	63		St. Peter P't, Grange Rd	3·04	77	129

Rainfall: August, 1925: Scotland and Ireland

CO.	STATION	In.	mm.	Per-cent. of Av.	CO.	STATION.	In.	mm.	Per-cent of Av.
Wigt.	Stoneykirk, Ardwell Ho	1·79	45	48	*Suth.*	Loch More, Achfary...	5·13	130	88
„ .	Pt. William, Monreith .	3·20	81	...	*Caith*	Wick	1·85	47	67
Kirk.	Carsphairn, Shiel.	4·70	119	...	*Ork .*	Pomona, Deerness	2·21	56	77
„ .	Dumfries, Cargen.....	6·53	166	149	*Shet .*	Lerwick	2·39	61	79
Dum	Drumlanrig	3·36	85	79					
Roxb	Branxholme	4·05	103	126	*Cork.*	Caheragh Rectory	3·92	100	...
Selk .	Ettrick Manse.....	5·66	144	...	„ ..	Dunmanway Rectory.	3·28	83	70
Berk.	Marchmont House	3·22	82	97	„ ..	Ballinacurra	4·03	102	108
Hadd	North Berwick Res....	2·29	58	72	„ ..	Glanmire, Lota Lo. ...	2·73	69	75
Midl	Edinburgh, Roy. Obs..	3·46	88	117	*Kerry*	Valencia Obsy.	3·81	97	80
Lan .	Biggar	2·62	67	79	„ .	Gearahameen	4·70	119	...
Ayr .	Kilmarnock, Agric. C..	3·51	89	90	„ .	Killarney Asylum.....	3·76	95	85
„ .	Girvan, Pinmore.....	3·00	76	67	„ .	Darrynane Abbey	4·04	103	93
Renf.	Glasgow, Queen's Pk..	3·48	88	98	*Wat .*	Waterford, Brook Lo..	4·54	115	119
„ .	Greenock, Prospect H..	4·25	108	78	*Tip .*	Nenagh, Cas. Lough...	1·77	45	45
Bute.	Rothesay, Ardencraig.	5·64	143	116	„ .	Tipperary	2·41	61	...
„ .	Dougarie Lodge	3·17	81	...	„ .	Cashel, Ballinamona ..	2·37	60	67
Arg .	Ardgour House	6·16	157	...	*Lim .*	Foynes, Coolnanes	1·82	46	47
„ .	Manse of Glenorchy..	5·25	133	...	„ .	Castleconnell Rec.	2·10	53	...
„ .	Oban	3·47	88	...	*Clare*	Inagh, Mount Callan ..	3·38	86	...
„ .	Poltalloch	4·03	102	82	„ .	Broadford, Hurdlest'n.	2·81	71	...
„ .	Inveraray Castle.....	5·85	149	89	*Wexf*	Newtownbarry	2·81	71	...
„ .	Islay, Eallabus.....	3·87	98	89	„ .	Gorey, Courtown Ho...	2·49	63	75
„ .	Mull, Benmore	9·40	239	...	*Kilk.*	Kilkenny Castle	1·83	47	53
Kinr.	Loch Leven Sluice	3·74	95	98	*Wic .*	Rathnew, Clonmannon	1·82	46	...
Perth	Loch Dhu	7·15	182	106	*Carl .*	Hacketstown Rectory .	2·89	73	71
„ ..	Balquhidder, Stronvar.	4·54	115	75	*QCo..*	Blandsfort House.....	1·93	49	49
„ ..	Crieff, Strathearn Hyd.	4·31	109	102	„	Mountmellick	2·52	64	...
„ ..	Blair Castle Gardens ..	2·94	75	87	*KCo.*	Birr Castle.....	1·83	46	48
„ .	Coupar Angus School..	3·45	88	104	*Dubl.*	Dublin, FitzWm. Sq...	1·17	30	38
Forf.	Dundee, E. Necropolis.	1·81	46	55	„ .	Balbriggan, Ardgillan .	2·17	55	64
„ .	Pearsie House.....	3·73	95	...	*Me'th*	Drogheda, Mornington	2·82	72	...
„ .	Montrose, Sunnyside..	2·18	55	78	„ .	Kells, Headfort.....	2·41	61	58
Aber.	Braemar, Bank	2·07	53	62	*W.M*	Mullingar, Belvedere .	2·59	66	62
„ .	Logie Coldstone Sch. ..	1·30	33	41	*Long*	Castle Forbes Gdns....	1·77	45	43
„ .	Aberdeen, Cranford Ho	...	...	...	*Gal .*	Ballynahinch Castle ..	5·21	132	95
„ .	Fyvie Castle	·82	21	...	*Mayo*	Mallaranny.....	6·49	165	...
Mor .	Gordon Castle.....	1·60	41	50	„ .	Westport House.....	3·50	89	86
„	Grantown-on-Spey....	1·28	33	40	„ .	Delphi Lodge	8·80	223	...
Na .	Nairn, Delnies.....	·98	25	41	*Sligo*	Markree Obsy.	3·65	93	85
Inv..	Ben Alder Lodge	2·67	68	...	*Cav'n*	Belturbet, Cloverhill..	2·22	56	60
„ .	Kingussie, The Birches	1·51	38	...	*Ferm*	Enniskillen, Portora ..	...	...	...
„ .	Loch Quoich, Loan....	5·50	140	...	*Arm.*	Armagh Obsy.	1·85	47	51
„ .	Glenquoich	4·57	116	56	*Down*	Warrenpoint	2·78	71	...
„ .	Inverness, Culduthel R.	·94	24	...	„ .	Seaforde	1·70	43	45
„ .	Arisaig, Faire-na-Squir	3·46	88	...	„ .	Donaghadee, C. Stn...	1·39	35	42
„ .	Fort William.....	4·38	111	71	„ .	Banbridge, Milltown .	2·03	52	58
„ .	Skye, Dunvegan.....	3·71	94	...	*Antr.*	Belfast, Cavehill Rd. .	2·13	54	...
„ .	Barra, Castlebay	1·47	37	...	„ .	Glenarm Castle.....	1·32	33	...
R&C	Alness, Ardross Cas. ..	1·51	38	51	„ .	Ballymena, Harryville	2·17	55	51
„ .	Ullapool.....	2·81	71	...	*Lon .*	Londonderry, Creggan	2·75	70	59
„ .	Torridon, Bendamph..	4·20	107	64	*Tyr .*	Donaghmore	2·45	62	...
„ .	Achnashellach	3·37	86	...	„ .	Omagh, Edenfel	...	...	...
„ .	Stornoway	3·16	80	80	*Don .*	Malin Head	3·01	77	86
Suth.	Lairg	1·16	29	...	„ .	Rathmullen.....	2·54	65	...
„ .	Tongue Manse.....	2·67	68	83	„ .	Dunfanaghy	4·48	114	102
„ .	Melvich School.....	2·32	59	78	„ .	Killybegs, Rockmount.	4·72	120	84

Climatological Table for the British Empire, March, 1925

STATIONS	PRESSURE		TEMPERATURE							Relative Humidity	Mean Cloud Am'nt	PRECIPITATION			BRIGHT SUNSHINE	
	Mean of Day M.S.L.	Diff. from Normal	Absolute		Mean Values				Mean Wet Bulb.			Am'nt	Diff. from Normal	Days	Hours per day	Percentage of possible.
			Max.	Min.	Max.	Min.	½ max. and min.	Diff. from Normal								
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0—10	mm.	mm.			
London, Kew Obsy.	1021·9	+ 8·5	53	25	47·1	35·8	41·5	− 0·9	36·2	86	6·5	11	− 32	10	2·6	22
Gibraltar	1014·9	− 2·1	67	41	58·9	47·9	53·4	− 4·1	47·2	78	5·4	151	+ 29	10	...	...
Malta	1013·2	− 1·6	70	45	59·5	51·4	55·5	− 1·6	50·6	79	5·7	152	+114	11	5·7	48
Sierra Leone	1011·0	+ 0·1	93	71	90·2	73·0	81·6	− 1·1	74·7	68	3·4	4	− 24	1	...	...
Lagos, Nigeria	1007·6	− 1·8	93	70	89·1	77·4	83·3	+ 0·4	77·5	76	7·4	168	+ 72	10	...	...
Kaduna, Nigeria	1010·4	− 0·7	99	...	93·4	...	...	...	69·4	51	0·6	11	0	3	...	...
Zomba, Nyasaland	1008·4	− 1·8	87	63	81·0	64·4	72·7	+ 1·8	...	90	8·8	313	+ 84	22	...	...
Salisbury, Rhodesia	1008·3	− 2·3	81	54	76·7	59·9	68·3	+ 0·2	62·7	78	6·9	213	+106	18	5·9	48
Cape Town	1013·4	− 0·9	100	55	80·4	61·3	70·9	+ 2·5	61·6	72	3·1	1	− 21	1	...	...
Johannesburg	1012·4	− 1·5	79	46	71·8	54·3	63·1	− 0·2	57·3	87	7·8	156	+ 49	22	4·7	39
Mauritius	1013·8	+ 1·8	88	66	84·7	70·9	77·8	− 0·2	73·8	72	5·9	123	−115	21	7·7	63
Bloemfontein	...	...	82	49	75·7	53·6	64·7	− 2·7	60·9	81	5·6	146	+ 45	13	...	...
Calcutta, Alipore Obsy.	1009·2	− 0·7	103	57	93·3	69·4	81·3	+ 1·2	69·7	82	3·2	12	− 25	*1	...	...
Bombay	1009·5	− 1·4	95	67	89·1	74·4	81·7	+ 2·2	71·7	70	2·1	0	− 1	*0	...	...
Madras	1010·0	− 0·9	93	67	88·3	71·9	80·1	− 1·0	75·1	81	4·2	73	+ 68	*2	...	...
Colombo, Ceylon	1009·2	− 1·2	92	71	87·2	73·7	80·5	− 0·8	76·4	71	6·6	186	+ 71	15	6·4	53
Hong Kong	1014·9	− 1·2	79	55	67·7	60·6	64·1	+ 0·8	60·0	80	7·4	210	+139	13	3·7	31
Sandakan	...	...	88	73	84·4	74·3	79·3	− 1·8	75·7	83	...	290	+ 84	21	...	...
Sydney	1016·9	+ 0·7	82	51	74·9	61·2	68·1	− 1·2	63·9	72	7·5	77	− 49	15	5·9	48
Melbourne	1017·4	+ 0·4	91	43	73·8	54·4	64·1	− 0·4	57·0	64	6·8	16	− 41	7	6·6	53
Adelaide	1016·6	− 0·4	97	47	82·1	58·9	70·5	+ 0·6	58·4	43	3·6	10	− 16	3	8·9	73
Perth, W. Australia	1014·1	− 1·2	94	54	80·1	62·4	71·3	+ 0·2	63·9	64	5·0	30	+ 11	7	7·3	59
Coolgardie	1013·6	− 1·2	99	50	81·8	60·9	71·3	− 0·4	60·3	59	5·6	24	+ 5	5	...	...
Brisbane	1013·3	− 1·1	95	61	78·8	70·6	74·7	+ 0·4	66·9	73	6·7	235	+ 87	18	4·3	35
Hobart, Tasmania	1015·5	+ 1·5	83	42	66·5	49·8	58·1	− 1·3	51·6	67	6·0	58	+ 15	9	6·9	56
Wellington, N.Z.	1016·0	− 1·0	75	41	67·3	53·2	60·3	− 0·1	55·6	65	5·5	53	− 30	5	6·7	54
Suva, Fiji	1006·7	− 1·8	90	71	87·5	73·4	80·5	+ 0·4	75·9	80	6·5	163	−210	20	...	...
Apia, Samoa	1009·4	+ 0·2	88	73	84·0	74·7	79·3	0·0	76·8	79	6·5	331	− 13	25	5·1	42
Kingston, Jamaica	1014·4	− 0·5	90	63	85·9	65·9	75·9	− 1·2	65·0	81	3·2	25	− 1	5	...	...
Grenada, W.I.	1013·1	+ 0·2	88	69	83·6	71·5	77·5	− 0·2	71·9	70	5·2	57	− 13	14	...	...
Toronto	1017·5	+ 0·5	62	1	42·0	27·7	34·9	+ 6·0	29·4	72	6·0	73	+ 6	13	4·4	37
Winnipeg	1018·0	− 0·8	55	−25	29·3	10·8	20·1	+ 5·7	...	...	5·6	50	+ 23	9	4·4	37
St. John, N.B.	1018·3	+ 4·1	62	9	40·8	26·8	33·8	+ 5·4	29·2	79	6·7	123	+ 8	16	4·7	39
Victoria, B.C.	1018·8	+ 3·0	55	35	50·0	39·5	44·7	+ 1·5	39·1	85	6·3	51	− 14	14	4·8	41

* For Indian stations a rain day is a day on which 0·1 in. (2·5 mm.) or more rain has fallen.

Victoria, B.C.	1018·8	+ 3·0	55	35	50·0	39·5	44·7	+ 1·5	39·1	85	6·3	51	− 14	14	4·8	41

* For Indian stations a rain day is a day on which 0·1 in. (2·5 mm.) or more rain has fallen.